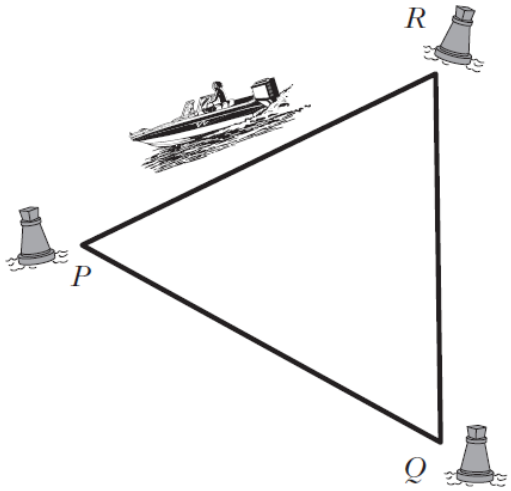
Resultant/Relative Position, Velocity and Acceleration

2004	**C2.**	At 2 pm, a ferry leaves port O travelling at $25\sqrt{2}$ km/h in a north-easterly direction. At the same time, a liner is 10 km east of O and travelling due north at 20 km/h. Both velocities remain constant. (*a*) By choosing an appropriate rectangular coordinate system with origin O, find the position of the ferry relative to the liner at time t, measured in hours from 2 pm. **4** (*b*) Calculate the distance between the ferry and the liner at 3 pm. **2**
2005 SP	**6.**	(*b*) Two cars have the same acceleration vector $8\mathbf{j}$ referred to rectangular axes Ox, Oy, where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors in the directions of Ox and Oy respectively. The first car P starts from position $12\mathbf{j}$ with initial velocity $2\mathbf{i}$ and the second car Q starts from position $6\mathbf{i}$ with initial velocity $4\mathbf{j}$. Show that the cars are travelling with constant velocity relative to each other and find the magnitude of this relative velocity. **4**
2006	**A3.**	A lift is initially at rest at ground level. It begins to accelerate upwards at $\frac{1}{8}g$ m s^{-2}. At the same instant, a light bulb in the ceiling of the lift begins to fall towards the lift floor. The initial distance between the lift floor and the light bulb is 2 metres. (*a*) Measuring distances in metres relative to the ground level, show that the position of the light bulb relative to the lift floor is $$\left(2-\frac{9}{16}gt^2\right)\mathbf{j},$$ where $\mathbf{j}$ is the unit vector in the upward vertical direction, and t is the time in seconds from the start of the motion of the lift. **3** (*b*) Calculate the distance the light bulb falls before hitting the lift floor. **3**
2009	**A5.**	An aircraft is flying from airport A to airport B, which is 500 kilometres from A on a bearing of 100°. A wind, with speed 70 kilometres per hour, is blowing from the south throughout the flight. The speed of the aircraft in still air is 350 kilometres per hour. Calculate the bearing on which the aircraft should fly to reach B. **3**
2014	**A7.**	A lift is initially at rest at the top of a building. At the instant the lift begins to descend with acceleration $\frac{1}{9}g$ m s^{-2}, a man in the lift releases a ball from a height of 1 metre above the lift floor by throwing it vertically upwards with a speed of 3·5 m s^{-1}. The man then allows the ball to fall to the floor. Assuming that the ball does not strike the ceiling of the lift, find the time taken for the ball to hit the floor from its moment of release. **7**

2013

A9. As part of a race, a speedboat has to round three buoys P, Q and R, starting at P and travelling anti-clockwise. The buoys are 200 metres from each other with R due North of Q and P lying to the west of the line QR. In still water, the speedboat travels at $20\,\text{m s}^{-1}$. The water current is steady at $5\,\text{m s}^{-1}$ flowing from due West.



Find the mean speed for one complete lap of the course. **9**

2016

12. An aircraft flies 1080 km due east from Glasgow to Copenhagen in a time of $2\frac{1}{4}$ hours.

The aircraft sets a course on a bearing of 100° and the speed of the aircraft in still air is $450\,\text{km h}^{-1}$.

(a) Calculate the magnitude and direction of the wind. **3**

(b) (i) Given that the velocity of the wind remains constant, explain why the return journey will take longer. **1**

(ii) Calculate how much longer the return journey will take, giving your answer to the nearest minute. **4**

2017

14. A fishing boat, A, leaves a harbour with a constant speed of $10\,\text{km h}^{-1}$ on a bearing of 060°.

At the same time another fishing boat, B, is 12 km due east of A, moving with a constant speed of $10\sqrt{3}\,\text{km h}^{-1}$ on a bearing of 330°.

(a) (i) Describe how the vectors $\mathbf{i}$ and $\mathbf{j}$ should be defined in this situation. **2**

(ii) Show that the position of boat A relative to boat B, t hours after A has left the harbour, can be written as ${}_{\text{A}}\mathbf{r}_{\text{B}} = \left(10\sqrt{3}t - 12\right)\mathbf{i} - 10t\,\mathbf{j}$ kilometres. **3**

(b) Find for how long the two boats will be within 7 km of each other. Give your answer to the nearest minute. **5**